Problem Set 2

CSE 452 / CSE M552

April 28, 2017

Submit short, **typeset** answers to the following questions. Please work on this individually. You may not use skip days on this assignment.

Problem 1: Lamport clocks

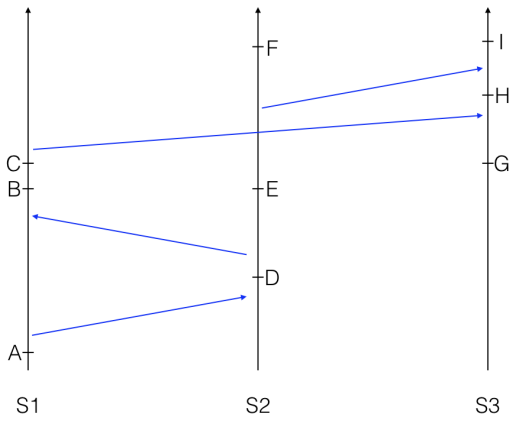

Figure 1: Spacetime diagram

Figure 1 is a Lamport space-time diagram. Assuming that the labeled events (plus message sends and receives) are the only events, that all of the clocks start at 0, that clocks are incremented before assigning a timestamp to an event, and that clocks are incremented when both sending and receiving messages, give the timestamps for the labeled events. Hint: A has timestamp 1 and D has timestamp 4.

Problem 2: Snapshots

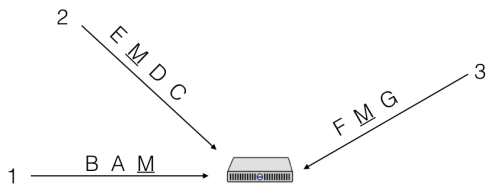

Figure 2: Snapshot in progress

Figure 2 shows a node in a distributed system that is executing the Chandy-Lamport snapshot protocol, along with all of its incoming channels and the (ordered) in-flight messages on each channel (the underlined "M" messages are snapshot markers). Assuming that the node has not started its snapshot, list all of the possible combined snapshot states for the three incoming channels. Hint: one such state is

```
1: []
2: [C, D]
3: [F]
```

Problem 3: Write-through caches and invalidation

```
1: put(k2, get(k1) + 1)
2: put(k2, get(k2) + 1)
```

Figure 3: Client 1 code

```
3: put(k1, get(k2) + 1)
4: put(k1, get(k1) + 1)
```

Figure 4: Client 2 code

Figures 3 and 4 show pseudocode for two clients of a simple key-value store. Assume that all keys start at 0, that the statements are executed in the listed order (1, 2, 3, 4), and that each client has its own cache which starts out empty. Show the states of both caches plus the server *after* each statement is executed, if the caches use a write-through protocol with invalidations.

Problem 4: Write-back caches and invalidation

Do the previous problem again, except assume that the caches use an MSI-type write-back protocol with invalidations (instead of the write-through protocol).